Vegetation Resources Inventory

Quality Assurance Procedures for Photo Interpretation

Prepared by
Ministry of Sustainable Resource Management
Resource Information Branch
for the Terrestrial Ecosystems Task Force
Resources Information Standards Committee

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For further information about the Resources Information Standards Committee, please access the RISC website at: http://srmwww.gov.bc.ca/risc/.

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Introduction

1.1. Background

The first version of the Quality Assurance procedures for Photo interpretation were released in 1998 and provided standards for the Ministry of Forests acceptance of Vegetation Resources Inventory (VRI) photo-interpreted inventories.

In 2002, changes in government and contract administration (e.g., the development of the Ministry of Sustainable Resource Management, the Forest Investment Account funding initiative and the contract administration by Price Waterhouse Coopers) have necessitated updating of these standards.

2002 updates to the original standards are very minimal. The most significant change is addressed in section "2.2 Process" and requires that all 3rd party quality assurance reports must be sent to the Ministry of Sustainable Resource Management (MSRM) VRI regional representative in the newly formed service or contact centers. If you require a contact name, please visit the following web site: http://srmwww.gov.bc.ca/tib/vri/vri/contactinfo.html

These standards will be updated during 2004 to reflect the use of digital "softcopy" technology and the RISC format. If you have questions regarding these standards, please contact a MSRM representative at the above web site.

In the past, photo interpretation quality assurance was achieved by obtaining a sample of the photo interpretation work of a contractor and by having a Ministry of Sustainable Resource Management (MSRM) photo interpreter check to ensure that it met MSRM standards. The main objective was to approve the contractor's work prior to payment.

A number of guidelines were specified against which the MSRM interpreter judged the work of the contractor. A scoring system was established to evaluate the checked polygons, and a passing grade was provided to assist in the evaluation. If the contractor's overall score did not exceed the minimum required, their work failed the test, and they were required to go over the work again to correct the problem.

The weakness of the system was that it was based on one interpreter checking another interpreter's work. Both interpreters could agree, but they could both be wrong in relation to what was on the ground. There was also the possibility that the MSRM interpreter's judgment could be wrong, whereas the contractor was correct. This quality assurance process was subjective and, based on the Inventory Audit results, the work that was passed by the MSRM interpreter might, in reality, not meet the standards if the decision were based on a ground sample. The audit samples showed that species composition identification was wrong on 30 to 50% of the polygons in most of the management units.

1.2. Inventory Design

The sample design recommended by the Vegetation Inventory Working Group (VIWG) for the BC Vegetation Resources Inventory (VRI) consists of two phases. In the Photo Interpretation Phase, aerial photographs are used to delineate boundaries of areas with

uniform vegetation composition and to estimate vegetation attributes. The delineation process forms polygons.

In the Ground Sampling Phase, a sample of the formed polygons is selected for ground sampling. The sample polygon data, after ground measurement, consists of photo estimated attributes and corresponding ground measurements. Regression or ratio relationships are established between the ground measurements and the photo estimates. These relationships are then used to adjust equally the photo estimated attributes for all polygons, those which were visited on the ground and those which were not visited.

Quality assurance has been identified as a reliable means of ensuring that both the Photo Interpretation and Ground Sampling data meet the Ministry of Sustainable Resource Management standards approved by the Resources Information Standards Committee (RISC).

1.3. Objectives of Photo Interpretation Quality Assurance

The objectives of conducting quality assurance for Photo Interpretation encompass the determination of both consistency and accuracy. Generally, the objectives can be stated as follows:

1. To improve the quality of photo interpretation through interactive evaluation, feedback and training.

2. To determine the performance of the individual interpreters in relation to the characteristics as measured by field observations.

3. To ensure the maintenance of specified MSRM photo interpretation standards prior to payment to a contractor.

4. To evaluate the efficiency of an interpreter's estimates for attribute adjustment using Ground Sampling data.

5. To ensure the data will load to MSRM corporate data systems and meet the business needs of government, industry and the general public.

The first objective relates to improving the quality of the photo estimation phase over time, with the objective of increasing the efficiency of the process.

The third objective is an evaluation of accuracy and has a bearing on whether or not a contractor is paid for the work. The MSRM expects the work of an interpreter to bear a relationship with what is on the ground. To that end, standards are set to create a quality assurance system that evaluates the relationship between ground and photo attributes and that at the same time is credible and fair to all contractors. The timeliness and fairness of the quality assurance process will be addressed as a separate issue.

The other objectives relate to evaluating consistency and ensuring data will load to corporate data storage systems. This evaluation provides us with information on how well the estimates will assist in the adjustment process. The ideal way to check the consistency is to compare the interpreter's estimate with the ground values as measured by randomly selected field observations. Verification of consistency is therefore a more rigorous process, requiring intensive sampling of a number of polygons from each photo interpreter.

2. Photo Interpretation Quality Assurance

2.1. Overview of Photo Interpretation

The work that leads to the production of a vegetation inventory data set consists of five major stages, which are:

1. data source transfer (including photo preparation);
2. polygon delineation;
3. field calibration (this may not be required in some instances);
4. attribute estimation and land cover identification; and
5. digital capture of attribute and graphic information

The first stage, data source transfer, consists of preparation of aerial photos and the migration of historical air and ground-based data to the inventory photos from which the new photo interpretation will be made. This source information is useful in photo interpretation calibration.

During the second stage, boundaries are drawn around areas with uniform vegetated and non-vegetated cover. This process creates vegetation cover polygons.

The field calibration stage is used to familiarize the photo interpreters with the local vegetation conditions. This is accomplished by the interpreter selecting representative areas within selected polygons for which they anticipate having difficulty in attribute estimation. By visiting these stands, they build a mental picture of what attributes should be assigned to stands of similar structure, tone and texture on aerial photographs.

The attribute estimation and land cover identification occur after the field calibration stage. At this stage, the interpreter uses historical data, their field calibration experience and interpretive skills to assign land cover classification and interpret species composition, height, age, density, basal area and other vegetation attributes on each delineated polygon. The interpretation is normally conducted using a 2-4 power stereoscope on mid-scale aerial photo pairs.

The final stage of the inventory process involves the digital capture of photo interpreted estimates and the graphic line work of each polygon. This stage will be the subject of other documents and is separate from this quality assurance process.

2.2. Process

Quality assurance will occur throughout all stages of the interpretation process. The various stages all have products that can be evaluated on an individual basis or in combination. To ensure quality products and timely payment, the primary contractor and the 3rd party quality assurance contractor should schedule the submission of products in batches at planned points

throughout the duration of the contract. The ensuing quality assurance should allow a quick assessment of the contractor's work, improve the product quality and enable payment to be authorized in a timely and efficient manner.

As the contractor submits each completed batch of photo interpretation work, the 3rd party quality assurance contractor should obtain samples of the work and check to ensure that Ministry standards are being met. The products provided by the separate stages can be assessed in two steps, namely, "initial quality assurance" and "final quality assurance." The initial quality assurance check provides feedback to the interpreters upon delivery of each batch of product and gives them an opportunity to improve the quality of their work. This step provides the means for approving partial payments prior to the completion of the "final quality assurance."

The licensee administrator or the 3rd party quality assurance contractor has the option of using further "final quality assurance" for some stages, such as the attribute estimation stage. The final quality assurance will involve the use of ground calls, air calls, 70 mm photography or a combination of these to accomplish the final quality assurance check.

Regardless of the specific project management arrangement regarding the development of VRI photo-interpreted inventory products, the MSRM must receive copies of all 3rd party quality assurance reports. By providing these reports to the MSRM, government staff are able to track project deliverables and provide a final audit function prior to the data being loaded to the corporate data storage systems. If required, MSRM can act as an impartial arbitrator over any disagreements over the quality assurance assessment.

2.3. Procedures

The first quality assurance is conducted after the polygon delineation process. At this stage, the accuracy of data source transfer and the correctness of the polygon delineation is evaluated. The second quality assurance is conducted after the attribute estimation and land cover identification process. The third quality assurance occurs when the entire photo interpretation project is completed (see Figure 1).

2.3.1. Photo Preparation and Data Source Transfer

To simplify the quality assurance process, both the photo preparation and data source transfer are combined with the polygon delineation quality assurance. A sample of document photos from a submitted batch is selected for evaluation. The selection is conducted as follows:

1. Determine the number of inventory photos in the batch.

2. A minimum of 30 photos (or stereo pairs) or 10% of the submitted stereo pairs is selected for evaluation.

3. Obtain a listing of photo numbers by flight line.

4. Number the photos sequentially by flight line and photo sequence. The numbers should range from 1 to the total number of inventory photo pairs.

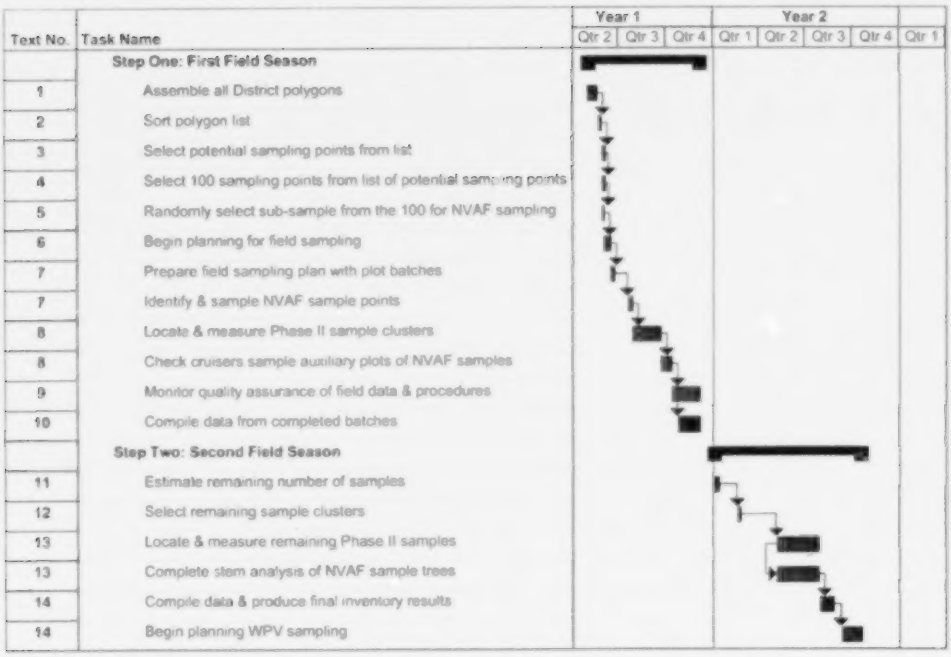
Text No.
Task Name
Year 1
Year 2
Qtr 2
Qtr 3
Qtr 4
Qtr 1
Qtr 2
Qtr 3
Qtr 4
Qtr 1
Step One: First Field Season
1 Assemble all District polygons
2 Sort polygon list
3 Select potential sampling points from list
4 Select 100 sampling points from list of potential sampling points
5 Randomly select sub-sample from the 100 for NVAF sampling
6 Begin planning for field sampling
7 Prepare field sampling plan with plot batches
7 Identify & sample NVAF sample points
8 Locate & measure Phase II sample clusters
8 Check cruisers sample auxiliary plots of NVAF samples
9 Monitor quality assurance of field data & procedures
10 Compile data from completed batches
Step Two: Second Field Season
11 Estimate remaining number of samples
12 Select remaining sample clusters
13 Locate & measure remaining Phase II samples
13 Complete stem analysis of NVAF sample trees
14 Compile data & produce final inventory results
14 Begin planning WPV sampling

Figure 1 - Quality Assurance Flowchart

5. Use a random number generator to produce as many random numbers as the sample size determined in step 2 above. The random numbers should be constrained to range from 1 to the number of inventory photo pairs.

6. Each random number identifies the photo set to be included in the sample.

7. The sample document photos are evaluated for accuracy of photo preparation, data source transfer and polygon delineation.

8. This quality assurance process should be conducted expediently so as not to hamper subsequent photo interpretation processes.

Air photo preparation evaluation

The purpose of the air photo preparation quality assurance is to ensure that the placement of principal point and fiducial marks, the definition of the flight line and the framing of the stereo overlap area, meet the MSRM standards. Lack of accuracy in photo preparation results in the production of inaccurate maps. The steps outlined below should be used in evaluating the photo preparation process (if applicable).

1. Evaluate the following:

   - line numbering;
   - north/south orientation;
   - unit boundary transfer on applicable photos;

- marking of the principal point;
- accuracy of the transfer of the conjugate points;
- preparation and marking of the effective photo interpretation; and
- transfer and extension of polygon boundaries across unit (project boundaries).

2. Record the above evaluation on the Photo Preparation Quality Assurance Rating.
3. Sign off the quality assurance:
    - Approve the product.
    - Return the batch to the contractor with instructions regarding items that do not meet standards and that need to be redone.

Table 1 - Air Photo Preparation Quality Assurance Standards

Attribute	Points Possible	Standards
Line numbering	1	Completed properly
North / south orientation	1	Completed properly
Unit boundary transfer	2	Within ± 10 mm
Principle point marking	2	Within ± 2 mm
Conjugate point marking	2	Within ± 5 mm
Mapping effective area	2	Good 2 Fair 1 Poor 0
Transfer of polygon at boundaries	4	Good 4 Fair 2 Poor 1
Total Possible	**14**	

Data source transfer evaluation

Data source transfer primarily involves four types of inventory data, which are:

- air call;
- ground call;
- temporary sample plot (TSP); and
- permanent sample plot (PSP) data.

The existence of any of this information in a delineated polygon is useful for calibration purposes. The assessment of the quality of the data source transfer is completed using a

statistically random sample of points. It is suggested that this quality assurance be completed in conjunction with the polygon delineation quality assurance.

1. Evaluate the following:
    - accuracy of data source placement;
    - extent;
    - symbology;
    - completeness of data; and
    - legibility.
2. Record the above evaluation on the Rating Table for Data Source Transfer.
3. Sign off the quality assurance:
    - Approve the product.
    - Return the batch to the contractor with instructions regarding items that do not meet standards and that are to be redone.

Table 2 - Data Source Transfer Quality Assurance Standards

Attribute	Points Possible	Standards
Accuracy of placement	2	Within ± 5 mm
Extent	1	Good 1 Poor 0
Symbology	2	Good 2 Fair 1 Poor 0
Completeness of data	4	Good 4 Fair 2 Poor 1
Legibility	1	Good 2 Fair 1 Poor 0
Total Possible	**10**	

Evaluation of polygon delineation

The purpose of the polygon delineation quality assurance is to determine whether a photo interpreter used the photo interpretation guidelines for indicating polygon boundaries appropriately. In many cases, polygon boundaries have no sharp, distinguishable boundaries, and each interpreter must use their judgment to determine where the lines are drawn. The lines should, however, follow logical break points such as potential changes in site productivity or changes in species composition.

The product of polygon delineation is a set of document photos with vegetation polygons demarcated in ink. The product is an aerial assessment; therefore it is not efficient to check it on the ground. The assessment for payment will be completed by a 3rd party quality assurance report, approved by the licensee administrator and PwC using a statistically random sample of polygons.

The quality assurance on polygon delineation should proceed as follows:

1. Evaluate the following:
    - accuracy of line placement;
    - minimum polygon size;
    - type separation;
    - consistency;
    - adherence to guidelines; and
    - neatness.
2. Record the above evaluation on the Rating Table for Polygon Delineation.
3. Sign off the quality assurance:
    - Approve the product.
    - Return the batch to the contractor with instructions regarding items that do not meet standards and that are to be redone.

Table 3 - Polygon Delineation Quality Assurance Standards

Attribute	Points Possible	Standards
Accuracy of line placement	2	Within ± 5 mm
Minimum polygon size	1	Good 1 Poor 0
Type separation	2	Good 2 Fair 1 Poor 0
Consistency	4	Good 4 Fair 2 Poor 1
Adherence to guidelines	6	Good 6 Fair 4 Poor 2

Attribute	Points Possible	Standards
Neatness	2	Good 2 Fair 1 Poor 0
Total Possible	**17**	

2.3.2. Field Calibration

Field calibration quality assurance procedures are still being developed. Future versions of this document will include this step of the photo interpretation quality assurance process. Procedures for the collection of field calibration data are indicated in other documents. For a copy of these documents, contact the Ministry of Sustainable Resource Management, Resource Information Branch.

2.3.3. Attribute Estimation and Land Cover Identification

The quality assurance for attribute estimation and land cover identification occurs after the attribute estimation stage of the photo interpretation process. This quality assurance is conducted through a combination of photo interpretation checks, air calls and ground checks. The photo interpretation evaluation considers all photo interpreted attributes. The air call evaluation checks attributes which are best evaluated by air. The ground evaluation establishes the ground "true" values for some of the attributes.

The 3rd party quality assurance photo interpretation estimates and the air calls assess the quality of the contract work for contract administration purposes. The ground data are used to evaluate photo interpretation consistency and may be used to establish consistency relationships between the photo estimates and the ground measurements – the "true" values.

All map sheets in a photo interpretation project undergo contract administration quality assurance. The process is as follows:

1. Obtain a complete listing of delineated polygons on each map sheet submitted by the contractor. The work of each interpreter in the project should be clearly identified.

2. Select 2% of the polygons from each map sheet for evaluation by a VRI Certified Photo Interpreter.

3. From the delineated polygon list, obtain a random sample of polygons to test.

Evaluation by 3rd party quality assurance contractor photo interpreter

4. For each sample polygon, obtain an independent estimate of all the land cover identification and attributes. A VRI Certified Photo Interpreter should be used to do this. The interpreter must not in any way have prior access to the estimates from the contractor.

5. The attributes to be estimated by the interpreter include all attributes identified on the attribute form that apply to a particular polygon. Some of these attributes may not be applicable to some sample polygons. When this is the case, the interpreter should code the attribute as specified in the photo interpretation procedures.

6. Compare the estimates of the interpreter with those of the contractor (by interpreter). Evaluate the difference between the two estimates. Use the system provided in Appendix A to conduct the evaluation.

Evaluation of photo estimates by air call

7. For the air call assessment, select a random subsample consisting of 20% of the polygons evaluated by the interpreter. (The air call assessment may occur concurrently with steps 4 and 5 above.)

8. For each polygon in the air call sample, obtain an independent estimation of relevant attributes. These include:

   a) Leading species age;
   b) Leading species height;
   c) Second species age;
   d) Second species height;
   e) Species #1;
   f) Species #1 %;
   g) Species #2;
   h) Species #2 %;
   i) Species #3;
   j) Species #3 %;
   k) Land cover comp. #1;
   l) LCC #1 % cover;
   m) LCC #2;
   n) LCC #2 % cover;
   o) LCC #3;
   p) LCC #3 %;
   q) Other LCC % cover; and
   r) Estimated SI species.

   Attributes listed in (a) to (d) are treated as continuous and are evaluated by assessing the contractor variability within an acceptable range. Those listed in (e) to (r) are treated as categorical and are evaluated on an agree-or-disagree basis.

9. Compare the air call estimates with the photo estimates provided by the contractor. Evaluate the difference between the two estimates. Use the system provided in Appendix B to do this.

10. Use the results from step 6 and step 9 above to determine whether the contractor's work meets the MSRM standards.

11. Pay the contractor for the submitted work if it meets the standards. If it does not meet the standard, reject the contractor's work and suggest changes that will make the work acceptable to the MSRM standard.

Evaluation by ground measurement

12. Randomly select 10% of the air call sample polygons for a ground evaluation. This evaluation may occur before or after the completion of the photo interpretation project.

NOTE: *The ground evaluation is primarily a check for photo interpretation consistency. It may affect the contract administration, in that a performance bond may be included in the contract to withhold a portion of the contract payment until the contractor's work passes a consistency evaluation test.*

13. The sample polygons involved in the consistency assessment are sampled intensively on the ground. Nine plots are established on a grid system within the sample polygon. Details on how the data will be collected from these polygons are provided in the Intensive Polygon Sampling Procedures.

14. The following attributes are considered for consistency evaluation:

    a) Leading species age;
    b) Leading species height;
    c) Second species age;
    d) Second species height;
    e) Basal area;
    f) Density (stems/ha); and
    g) Estimated site index.

15. Evaluate the consistency of photo interpretation using the process presented in Appendix C.

16. If the consistency evaluation meets MSRM standards, authorize final payment for the contractor's work. If the consistency evaluation does not meet MSRM standards, withhold the performance bond until the problem is corrected.

Appendix A: Process for Evaluation by Ministry of Sustainable Resource Management Interpreter

Ratio or continuous attributes are assessed by comparing the 3rd party quality assurance interpreter photo estimates against those of the contractor and determining whether the contractor estimates fall within the range of acceptable values as defined in the *Vegetation Resources Inventory Photo Interpretation Standards* (1998).

For the following attributes, the contractor's estimates are acceptable if they fall within the acceptable range of the 3rd party qa interpreter estimates:

a) Leading species age;
b) Leading species height;
c) Second species age;
d) Second species height;
e) Crown closure;
f) Basal area;
g) Density (stems/ha);
h) Snags (stems/ha);
i) Estimated site index;
j) Shrub height;
k) Shrub crown closure percent;
l) Herb cover percent;
m) Bryoid cover percent; and
n) Non-vegetated cover percent.

A penalty is imposed if the contractor estimates fall outside the acceptable range.

Categorical attributes are evaluated by establishing an agree-or-disagree criterion around each category of the attribute. A loss of points will be imposed if an interpreter made an attribute interpretation which does not agree with the quality assurance estimate.

The following attributes will be included in this category:

a) Surface expression;
b) Modifying process;
c) Site position meso;
d) Alpine designation;
e) Soil nutrient regime;
f) Land cover component #1;
g) LCC #1 percent cover;
h) LCC #1 SMR;
i) LCC #2;
j) LCC #2 percent cover;
k) LCC #2 SMR;
l) LCC #3;

m) LCC #3 percent cover;
n) LCC #3 SMR;
o) Other LCC percent cover;
p) Estimated SI species;
q) Tree cover pattern;
r) Tree layer;
s) Vertical complexity;
t) Species #1;
u) Species #1 percent;
v) Species #2;
w) Species #2 percent;
x) Species #3;
y) Species #3 percent;
z) Species #4;
aa) Species #4 percent;
ab) Species #5;
ac) Species #5 percent;
ad) Species #6;
ae) Species #6percent;
af) Shrub cover pattern;
ag) Herb cover type;
ah) Herb cover pattern;
ai) Non-vegetated cover type; and
aj) Non-vegetated cover pattern.

The scoring system for continuous attributes is shown in Table A.1.

Table A.1 - Evaluation of continuous attributes by MSRM interpreter

Attribute	SCORES			
	Estimate Within ± 15%	Estimate Within ± 20%	Estimate Outside ± 20%	Maximum Score Possible
Leading species age	6	3	0	6
Leading species height	10	8	0	10
Second species age	4	2	0	4
Second species height	8	3	0	8
Crown closure	2	2	0	2
Basal area	10	8	0	10
Density (stems/ha)	4	3	0	4
Snags (stems/ha)	4	2	0	4
Estimated site index	2	1	0	2
Shrub height	3	1	0	3
Shrub crown closure	2	1	0	2
Herb cover percent	3	1	0	3
Bryoid Cover percent	2	1	0	2

Attribute	SCORES			
	Estimate Within ± 15%	Estimate Within ± 20%	Estimate Outside ± 20%	Maximum Score Possible
Non-veg cover percent	3	1	0	3
Total Possible				63

The scoring system for categorical attributes is shown in Table A.2.

Table A.2 - Evaluation of categorical attributes by MSRM interpreter

Attribute	SCORE		
	Agreement with MSRM	Disagreement with MSRM	Maximum Score Possible
Surface expression	1	0	1
Modifying process	1	0	1
Site position meso	1	0	1
Alpine designation	1	0	1
Soil nutrient regime	2	1	2
Land cover component #1	2	1	2
LCC #1 percent	1	0	1
LCC #1 SMR	1	0	1
LCC #2	1	0	1
LCC #2 percent	1	0	1
LCC #2 SMR	1	0	1
LCC #3	1	0	1
LCC #3 percent	1	0	1
LCC #3 SMR	1	0	1
Other LCC percent	1	0	1
Estimated site index species	1	0	1
Tree cover pattern	1	0	1
Tree layer	1	0	1
Vertical complexity	1	0	1
Species #1	3	1	3
Species #1 percent	1	0	1
Species #2	2	0	1
Species #2 percent	1	0	1
Species #3	1	0	1

Attribute	SCORE		
	Agreement with MSRM	Disagreement with MSRM	Maximum Score Possible
Species #3 percent	1	0	1
Species #4	1	0	1
Species #4 percent	1	0	1
Species #5	1	0	1
Species #5 percent	1	0	1
Species #6	1	0	1
Species #6 percent	1	0	1
Shrub cover pattern	1	0	1
Herb cover type	1	0	1
Herb cover pattern	1	0	1
Non-vegetated cover type	1	0	1
Non-vegetated cover pattern	1	0	1
Total Possible			40

These two scoring systems require further testing and refinement and may be adjusted or altered depending upon the results of those tests.

Appendix B: Process for Evaluation by Air Call

The air call assessor should not have prior knowledge of the attribute estimates for the sample polygons under their consideration. The assessor should follow the steps outlined below:

1. Identify the target stereo pairs on which the sample polygons are located. Number all the eligible stereo pairs and ensure that they can be traced back to the original photo interpreter.

2. Obtain the appropriate evaluation forms for recording the assessment.

3. Study the distribution of the sample polygons in the project area and develop a flight plan.

4. Record UTM (or GPS) coordinates while over the sample polygon. These coordinates will be very useful in helping to ensure that the air call is placed in the correct polygon.

5. Fly across the sample polygon along the flight line. As this is happening, use a scratch pad to record estimates of attributes of interest.

6. If there is uncertainty about the estimation of some attributes, the assessor may request the helicopter pilot to fly according to any flight pattern that will provide them with the best opportunity to obtain the optimum information to provide a reliable evaluation.

7. When satisfactory evaluation is achieved, record the information on the official form.

8. The following information should be collected to assess the continuous and categorical attributes:

   Continuous attributes:

   a) Leading species age;
   b) Leading species height;
   c) Second species age;
   d) Second species height.

   Categorical attributes:

   e) Species #1;
   f) Species #1 percent;
   g) Species #2;
   h) Species #2 percent;
   i) Species #3;
   j) Species #3 percent;
   k) Land cover component #1;
   l) LCC #1 percent cover;
   m) LCC #2;

n) LCC #2 percent cover;
o) LCC #3;
p) LCC #3 percent cover;
q) Other LCC percent cover;
r) Estimated SI species.

9. Complete the air call estimation for all designated sample polygons before checking the accuracy of the interpreter estimates against the air call.

10. Obtain the attribute estimates provided by the interpreters.

11. Evaluate the work of the interpreters based on the scoring system below.

12. Document the strengths and weaknesses of each interpreter.

13. Submit the grades for analysis.

14. Obtain final assessment of each interpreter.

15. Discuss the results with the contractor and the interpreters, particularly those who submitted unsatisfactory work (if applicable).

16. Pay the contractor.

17. Submit copies of the quality assurance reports to the MSRM.

The scoring system for the continuous attributes is shown in Table B.1.

Table B.1 - Evaluation of continuous attributes by air call assessment

Attribute	SCORE			
	Estimate Within ± 15%	Estimate Within ± 20%	Estimate Outside ± 20%	Maximum Score Possible
Leading species age	6	3	0	6
Leading species height	10	8	0	10
Second species age	4	2	0	4
Second species height	8	3	0	8
Total possible				28

The scoring system for the categorical attributes is shown in Table B.2.

Table B.2 - Evaluation of categorical attributes by air call assessment

Attribute	SCORE		
	Agreement with MSRM	Disagreement with MSRM	Maximum Score Possible
Species #1	3	1	3
Species #1 percent	1	0	1

Species #2	2	0	2
Species #2 percent	1	0	1
Species #3	1	0	1
Species #3 percent	1	0	1
Land cover component #1	2	1	2
LCC #1 percent	1	0	1
LCC #2	1	0	1
LCC #2 percent	1	0	1
LCC #3	1	0	1
LCC #3 percent	1	0	1
Other LCC percent	1	0	1
Estimated SI species	1	0	1
Total Possible			18

Appendix C: Process for Evaluating Consistency

It has been emphasized repeatedly that *consistency* in inventory attribute estimation is a desired characteristic, and that its achievement would improve the efficiency of the adjustments. So what exactly is meant by the term *consistency* in relation to Photo Interpretation data?

Consistent implies a relationship of an estimate to the "true" value as measured on the ground. A photo estimate is consistent with the ground measured value if there is a (predictable) relationship between the two. Lack of consistency implies no relationship between the photo estimate and the ground measurement. Consistency may be described (measured) by deviation between the estimate and the ground value.

How does consistency relate to the ideas of bias, accuracy and precision? Is consistency the same as bias?

Bias is a systematic deviation from the "true" value. If two individuals interpret height on photos, and the heights of one are *consistently* 10% greater than those of the other, then we are describing the relationship between the two estimates of height (a continuous variable), and we may even say that the height estimate of one interpreter is *biased* compared with that of the other. (In the past we assumed that one interpreter, the Ministry auditor, represented the "true" or correct height.)

Does consistency imply bias (regardless of the magnitude)? In a sampling context, does adjustment for consistency (removing the deviation) lead to greater precision of estimates?

The answer to both questions is "not necessarily." If two individuals interpret height on photos, and the heights of one interpreter are *consistently* 10% greater than those of the other, but neither are *consistent* (biased) compared with the true heights, then the adjustment using a ratio/regression procedure to estimate true height doesn't improve precision of estimates (it may even inflate precision). This occurs since the requirement for improved precision of ratio/regression estimates is that there is a reasonably strong (linear) relation between the photo height (x) and the ground height (y). *Consistency* between two interpreters doesn't help if neither of them is related to the true heights; knowing the photo heights for either interpreter tells nothing about the true height even though there is *consistency*. From the perspective of sampling and adjustments, the use of interpreted photo variables is most useful if the photo variables are consistently related to the true (ground) variables.

Consistency Assessment

During the consistency assessment, an attempt is made to derive a relationship that characterizes the deviations of the photo estimates from the "true" ground measurement. If it exists, such a relationship is expressed in the form of an equation. Figure 2 illustrates the type of relationship that might characterize consistency. The relationship is defined as the negative slope line running through the data points. If an equation can be derived for such a relationship, the photo estimates can be adjusted to remove bias.